SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
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MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

September 1982
NSRP 0009

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Proceedings of the IREAPS Technical Symposium

Paper No. 26: Weld Acceptance Standards

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **SEP 1982**	2. REPORT TYPE **N/A**	3. DATES COVERED **-**

4. TITLE AND SUBTITLE **The National Shipbuilding Research Program, Proceedings of the IREAPS Technical Symposium Paper No. 26: Weld Acceptance Standards**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192 Room 128-9500 MacArthur Blvd Bethesda, MD 20817-5700**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**SAR**	**23**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

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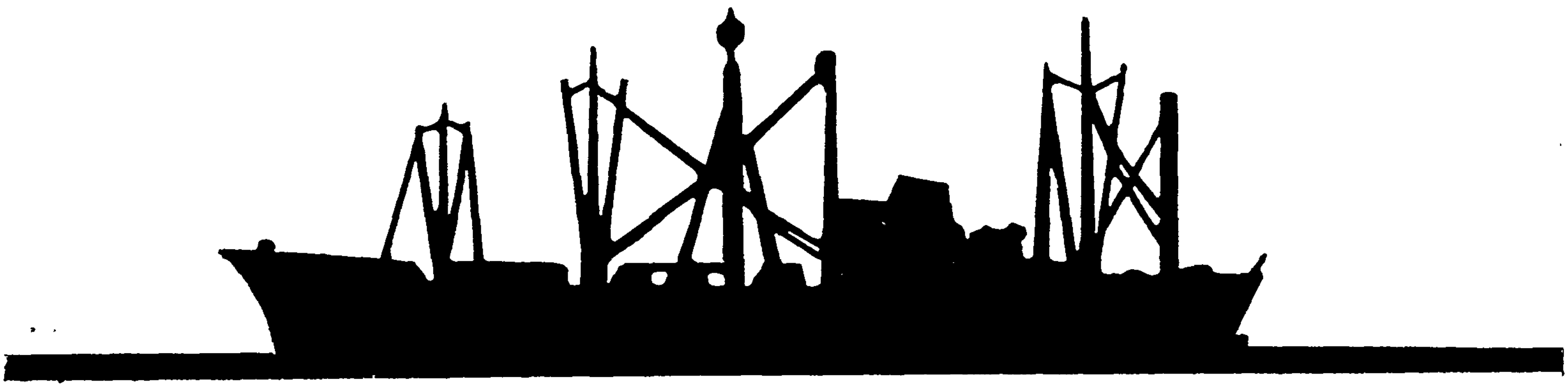
Proceedings
IREAPS Technical Symposium
September 14-16-1982
San Diego, California

VOLUME I



INSTITUTE FOR RESEARCH AND ENGINEERING FOR AUTOMATION AND PRODUCTIVITY IN SHIPBUILDING

I R E A P S

WELD ACCEPTANCE STANDARDS

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Mr. Alia began his career at the New York Naval Shipyard in 1955. He completed a 4-year apprenticeship program as a combination welder and worked as a journeyman welder, shop planner, and nondestructive testing technician in connection with construction of naval combatant ships. From 1956 to 1958, he served with the U.S. Army in Germany. In 1963, he joined the U.S. Naval Science Laboratory and was engaged in welding process development in connection with Navy deep submergence programs. In 1967, he joined the American Bureau of Shipping as a surveyor. In his present position with this international company, he is Head of Materials Engineering, Containers, and Quality Assurance Departments and is responsible for material selection, welding, fabrication and nondestructive testing in connection with ships, drilling rigs, offshore structures and other marine structures, administering quality assurance programs, and certification of ship containers. He has performed metallurgical consultant work for the ABS Group of Companies. Mr. Alia is the ABS representative on numerous AWS Committees including Chairman of the Welding in Marine Construction Committee. U.S. Representative on IIW - Commissions IX and X, a member of SNAME Ship Production Committee on Welding, and a member of ASME Subcommittee on Welding.

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Mr. Stern, has been employed as a Materials Engineer and Welding Engineer at the Brooklyn Navy Yard and served as Head Welding Section and Fabrication Program Manager. In the course of these duties he received the Navy Meritorious Civilian Service Award for his efforts in Steel Fabrication Development. In 1970, he joined the American Bureau of Shipping, and is currently Head of the Materials Engineering Section, which is responsible for material, welding, fabrication and nondestructive testing. He has written and presented numerous technical papers on materials, welding and nondestructive testing, among which is the Chapter on Hull Materials and Welding in the SNAME publication Ship Design and Construction.

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ABSTRACT

The presentation will cover the objectives and summarize the progress of MARAD SP-7 Panel programs on (a) development of reference standards for visual inspection welds, and (b) evaluation of the quality of existing ship welds by ultrasonics. The relationship of the visual acceptance standards; quality control procedures, quality of production welds and the significance of representing acceptance standards with model reference standards will be discussed.

Ultrasonic evaluation of the quality of existing ship welds will be related to the existing radiographic and ultrasonic examination' conducted outside areas required by the governing code or rules. This may occur in new construction or after various periods of service. Unnecessary repairs can be costly and at times can degrade rather than improve structural reliability; on the other hand, internal discontinuities that represent a significant degradation of structure should be repaired. The ultrasonic evaluation program will be related to the above as well as to the ABS guidelines to cover analogous cases.

This paper will describe two investigations conducted by ABS which were supported under MarAD auspices via the SNAME SP-7 Committee. One investigation was concerned with the radiographic and the ultrasonic examination of ship welds between intersections; the other with visual reference standards for weld surface examination. Both are directed toward areas where the weld acceptance standards are somewhat vague or non-existent and a source of confusion to inspectors and surveyors. In cases where acceptance criteria are not specific, controversy is encountered where the various parties concerned have differences of opinion as to the acceptability of a weld.

To approach the first problem, which is concerned with nondestructive inspection (NDT). of welds for internal soundness, we must understand the basis of our present requirements. In 1963 the AHS Rules only indicated that welds be inspected in important locations by an established radiographic technique. To develop a more specific requirement, a worldwide survey was conducted and various questions were asked of shipyards as to details of their inspection methods, their techniques and their acceptance standards. A proposed standard was offered for their consideration and comment. Results indicated that there was extensive use of NDT in shipyards, primarily x-ray and isotopes, and in a few cases ultrasonics. Standards used were ASME, Navy, IIW, JIS and some internal standards. Based on the results of the survey and the comments of the **shipyards,** the ABS "Guide for Radiographic Inspection of Hull Welds" was issued in 1965. The Guide specified where radiography should be conducted and the acceptance standards which would be applicable. In September 1971, the Guide was modified and reissued as "Requirements for Radiographic Inspection of Hull Welds".

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In 1969, ABS initiated the development of requirements for ultrasonic inspection which followed the same route as with radiography, i.e. looking at what is available, getting comments from the shipyards, and proposing standards. In 1972, ABS issued "Provisional Requirements for Ultrasonic Inspection of Hull Welds". After these were in use for several years, modifications were made based on industry comments, and the ABS "Rules for Nondestructive Inspection of Hull Welds" was promulgated in 1975 which included both radiography and ultrasonic inspection. These Rules indicate the extent of inspection, location of inspection and acceptance standards. Location is primarily midship, with random inspection being conducted outside the midship area. Within the midship, radiography or ultrasonics is specified to be conducted at "intersections of butts and seams in the shear strakes, bilge strakes, deck stringer and keel plates, and butts in and about hatch corners in main decks and in the vicinity of breaks in the superstructure". There are no speific requirements to perform radiography or ultrasonics between intersections. The problem we are addressing is that at times some additional radiography or ultrasonic inspection is conducted between intersections either at an owner's request or in connection with a shipyard's or other organizations initiative in checking welds. Since there are no specific acceptance standards, questions as to what is acceptable and what is not acceptable become a source of controversy, and in many cases unnecessary repairs are made because of the lack of definition of what is an acceptable or nonacceptable weld.

Possible solutions are to use the existing ABS Class A and Class B acceptance standards and apply them indiscriminately to all areas within the midship and outside midship locations respectively. However, to do this would mean that the shipyard was guaranteeing that all welds would meet such standards and

this would require 100% inspection of all its welds as is the general practice in the Boiler and Pressure Vessel industry. Service experience with ships indicates that this extensive inspection is unnecessary and uneconomical. on the other hand, to allow appropriate deviation from ABS Class A and Class B acceptance standards would require the development of a liberalized standard. This could be based on fitness for purpose in accordance with fracture mechanics concepts or service experience. The fitness for purpose concept has been ruled out because it requires consideration of too many factors which could not be taken into account for each individual weld due to shipyard and owner requirements that prompt decisions be made regarding acceptability of a particular weld. Service experience seems to be the logical approach. For this, we need information as to weld quality that has proven satisfactory in service.

A project of the MarAd/SP-7 Panel is to examine the welds between intersections in classed ships and *to* determine what has proven satisfactory in service. A problem encountered was the availability of ships; we found that there were not many ships that would be available. In general, organizations did not want their ships examined in areas where no inspection requirement existed. Fortunately, we did have a solution. The MarAd Ready Reserve Fleet was made available for inspection and a tentative acceptance standard that ABS has issued as a Guideline was used to evaluate the quality of welds in these ships. Our survey was conducted exclusively on deck welds, primarily at the 0.6L midship area, with 70% of our inspection carried out in this area. We did a proportionally higher than normal amount of inspection outside midship, namely 30%, because we expected that, if we were going to find welds that were of lesser quality, they could very well be outside the midships area. Ultrasonic examination was employed and we followed standard ABS procedures and used shipyard personnel, (Newport News personnel) to do the actual inspection. The reason

for selecting deck welds for examination was accessibility. Two acceptance levels were used as a basis for weld evaluation. (See Table A). One was the ABS Class A and B standards as specified in the ABS "Rules for Nondestructive Inspection of Hull Welds". The other was an ABS in-house Guideline that has been used in specific cases where the ship owner or ship designer and the shipyard do not have a meeting of minds as to the appropriate weld quality for random inspection. The ABS Guideline indicates that for butts between intersections in the midship areas, twice the ABS Class A acceptance criteria would be reasonable basis for acceptance and twice Class B for all seams between intersections and butts between intersections outside midship length. It was considered that for relatively unimportant areas for which less than twice Class B criteria could be tolerated, such areas should not be considered for evaluation by either radiography or ultrasonic inspection.

The survey consisted of 18 ships - containships, freighters, tankers and transports in the 400 to 600 ft. range which were built between 1943 to 1973. (See Table B). An average of 15 inspection locations for each ship were examined and each inspection consisted of a check point 24 in. long. These were the ships that were available; given a choice we would have included a few ships of more recent vintage. What is most surprising is the fact that comparatively few defects were found. Cut of the total 18 ships surveyed, only 7 ships showed any recordable indications for the locations inspected. For 11 of the ships, all of the inspected locations were sound and free of any significant ultrasonic indication. Of the 7 ships in which indications were found no conclusion could be drawn about the relationship between quality level and era of build.

Welds between intersections were evaluated with the standards that were previously mentioned, that is, either following the ABS Rules (Class A or B) or the ABS Guideline where we would apply twice Class A and twice Class B acceptance criteria.

The following results were obtained: Of the 195 midship inspection check points, 14 check points (7.2%) would not pass if the ABS Class A acceptance criteria was applied. Applying the more liberal guideline twice Class A for butts and twice Class B for seams, 11 check points (5.6%) would not meet the guideline. Of the 84 check points tested outside midship, 5 check points (6.0%) failed to meet the ABS Class B Rule Requirement and 4 check points (4.8%) failed to meet the more liberal guideline of twice Class B. There wasn't much difference between rejection under the ABS Rules or the more liberalized ABS Guideline acceptance standards - 19 rejections or (6.8%) versus 15 rejections or (5.3%). A summary of results is given in Table C. This trend was observed both within the midship and outside the midship area and applied to the length of discontinuity as well as the number of check points. For one ship we found the non-acceptance on the basis of ABS Rules was 6 check points (33.3%) as compared to 4 check points (22.2%). The overall quality of the ships examined was surprisingly good. Some significance may be attributed to the fact that only deck welds were examined and these welds were mainly made by submerged arc welding.

What was apparent was that reasonable liberalization does not result in significant repair reduction where the weld is of general good quality. It should be realized that all the above opinions are based on preliminary work and larger sampling is required before definite conclusions should be drawn. In addition, it would be interesting to survey the weld quality of ships built with current technology and make detailed comparisons between automatic versus semi-automatic or manual welding techniques.

The next part of the paper will be directed toward visual acceptance standards. For all major structures under construction, most of the weld inspection has to be visual. This involves looking at fillets and butts in various sections of ships. Our objective in developing visual acceptance standards was to clarify standards that can be more meaningful to the designer and regulator who specify standards and to the inspector who interprets the standards in the field. Visual acceptance standards should provide uniformity and reproducibility and be adaptable to codes. In addition, samples should be available which illustrate gradations of weld surface quality that are suitable for different applications. A review of available codes indicates that, in many cases, even though attempts are made to define surface appearance quantitatively, we find that the judgements of actual production welds must be subjective. There doesn't seem to be any suitable way to literally specify surface appearance that can relate to actual production welds.

We believe that visual acceptance reference standards could be useful to shipyards for internal standards, regulatory bodies for Rules and inspection, government agencies for specifications, owners and designers for their inspection and contracts and to technical societies. Eventually we hope these will prove useful for incorporating into specifications. An important objective is to acquire a universal understanding. Translation of a code into a foreign language very often could change the context of what is acceptable and not acceptable. Having an actual specimen to examine transcends all language difficulties.

The range of qualities of samples was determined after existing descriptive standards were surveyed. Our approach was to obtain samples of various surface irregularities with three gradations of quality which could ultimately

be selected for reference standards. Qualities selected were that which was interpreted as the average of acceptance specifications, one somewhat better in quality and one somewhat poorer. In the future, these could be made available as plastic models which could be widely distributed so that those concerned could physically see what the words of the specification are trying to describe.

The work was done by ABS under the auspices of the SNAME SP-7 Panel which consists of representatives of shipyards, ABS, Navy, Coast Guard, and MarAd. Seven shipyards contributed 350 samples of which 18 were finally selected as the reference standards. These samples were prepared using shielded metal arc, submerged arc, gas metal arc, and flux cored arc welding. Samples of undercut, scattered porosity and cluster porosity were categorized. The program was authorized in 1980. The major part of the time was spent in acquisition of the samples and it took almost a year with numerous discussions to get an agreement on the selection of the 18 reference samples. The 18 reference samples each 6 in. long consist of butts and fillets with 3 gradations of undercut, scattered porosity and cluster porosity. The 3 gradations are categorized in increasing severity as Classes A, B, and C. (See Table D). Figures A through F show the various samples with close-up enlargements of the irregularities. It is evident that it is very difficult to describe the irregularities in words.

In addition to reference standards, we provided tentative definitions or descriptions which might be considered, for adoption by industry and the codes. The initial program has been completed and the samples have been delivered to the SP-7 Panel which is arranging to have plastic models of the samples available. In the near future, comments will be solicited from industry, ABS and various regulatory agencies. After comments have been received and taken into account, the standards will be suitable for consideration by industry for adoption in their codes, Rules and specifications.

A follow up effort will be proposed to acquire samples for categories of other surface irregularities. One condition is roughness which is height differences within beads. Another is contour which includes overlap and re-entry angle.

We hope that this effort will minimize an area of controversy and eliminate an area that has been an irritant to many of the marine industry.

Table A Nondestructive Testing Acceptance Criteria

	AT INTERSECTIONS		BETWEEN INTERSECTIONS			
	Within Midship 0.6L	Outside Midship	Within Midship 0.6L		Outside Midship	
			Butts	Seams	Butts	Seams
ABS Rules	A	B	—	—	—	—
ABS Guidelines	A	B	2A	2B	2B	2B

Table B UT SURVEY—18 SHIPS 400-600 FT.

Type	No.	Year Built	Ships with recordable indications: No.	Ships with recordable indications: Year Built
Containers	3	'69(2), '73	1	'69
Freighters	9	'45(2), '52, '57, '59 '60(2), '61, '62	2	'52, '59
Tankers	1	'43	1	'43
Transports	5	'44(3), '45(2)	3	'44(2), '45
	18		7	

TABLE C

RESULTS OF UT SURVEY (18 SHIPS)

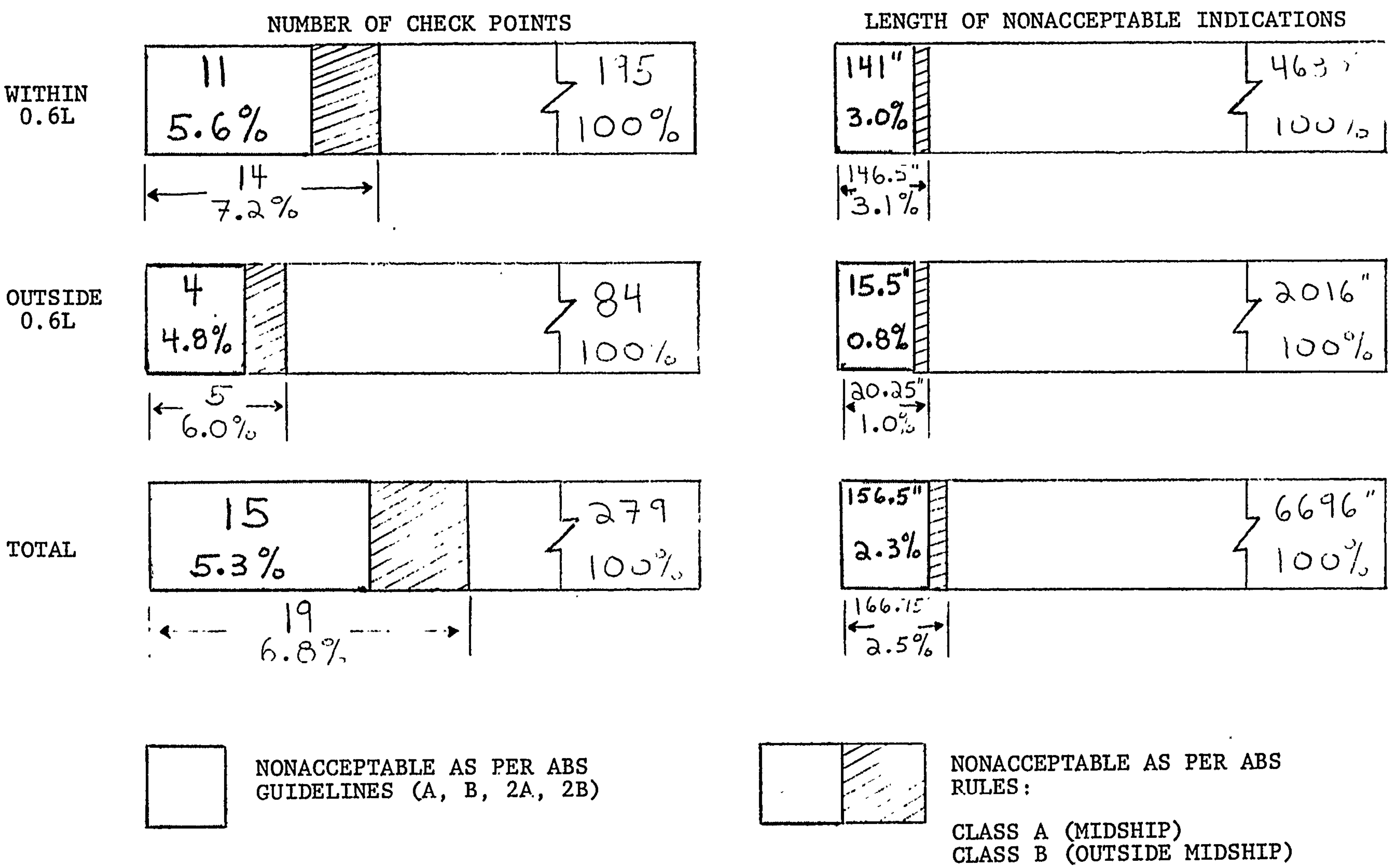

Table D

REFERENCE STANDARD CATEGORIES
(Butts and Fillets)

UNDERCUT

- Class A- l/64 in. continuous
- **Class B-1/32 in. continuous**
- **Class C-l/16 in.** continuous

SCATTERED POROSITY

- Class A-4 pores **(l/32 in.** max.)
- **Class B-4 pores (l/l6 in. max.)**
  or 7 pores (3/64 in. max.)
- Class C-4 pores (l/8 in. max.) or equivalent area

CLUSTER POROSITY

- **Class A-multiple pores (l/32 in.** max.)
  within l/4 inch-
- Class B-multiple pores within **l/2 inch**
- Class C-multiple pores within 1 inch

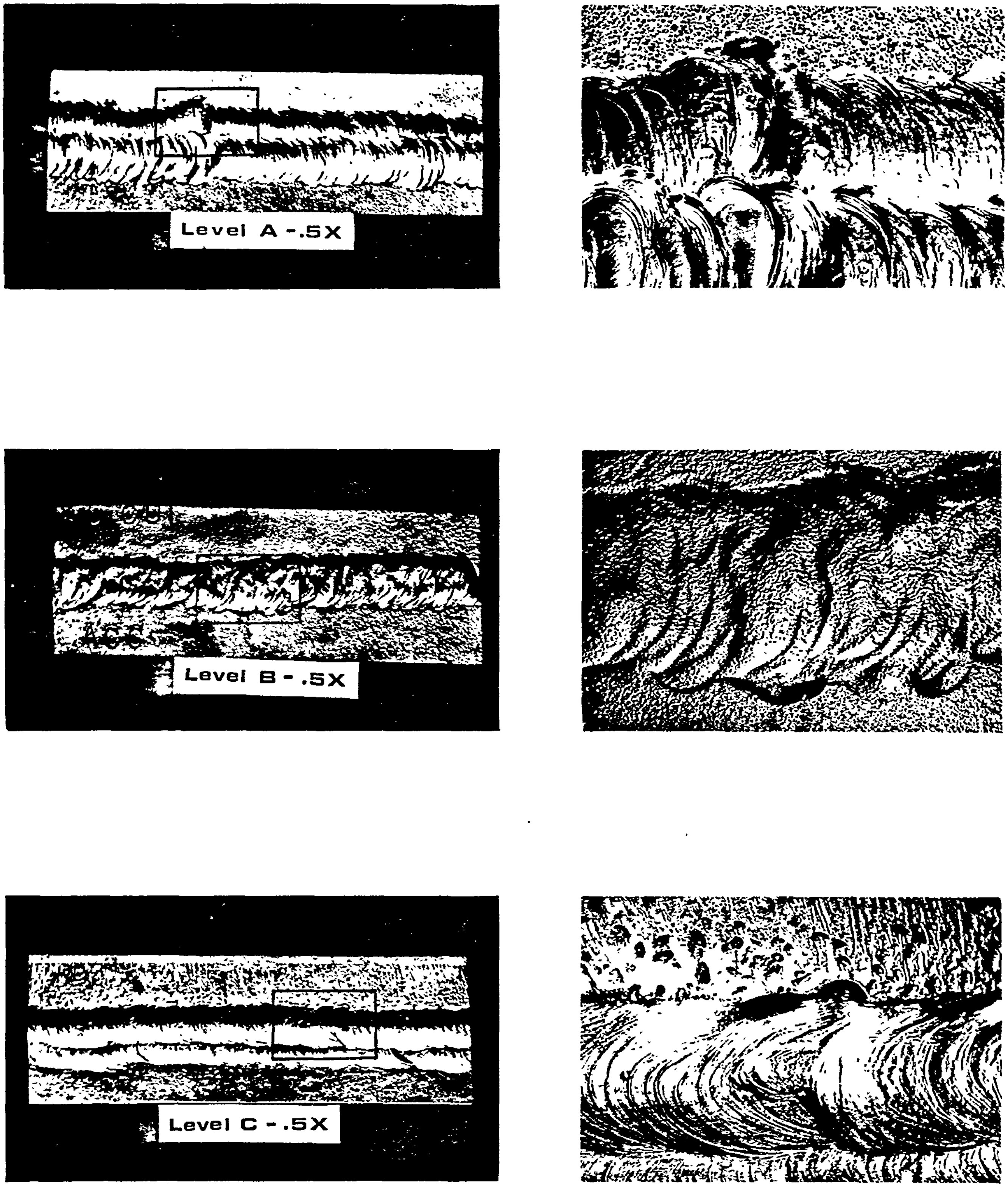

FIG. A: Undercut

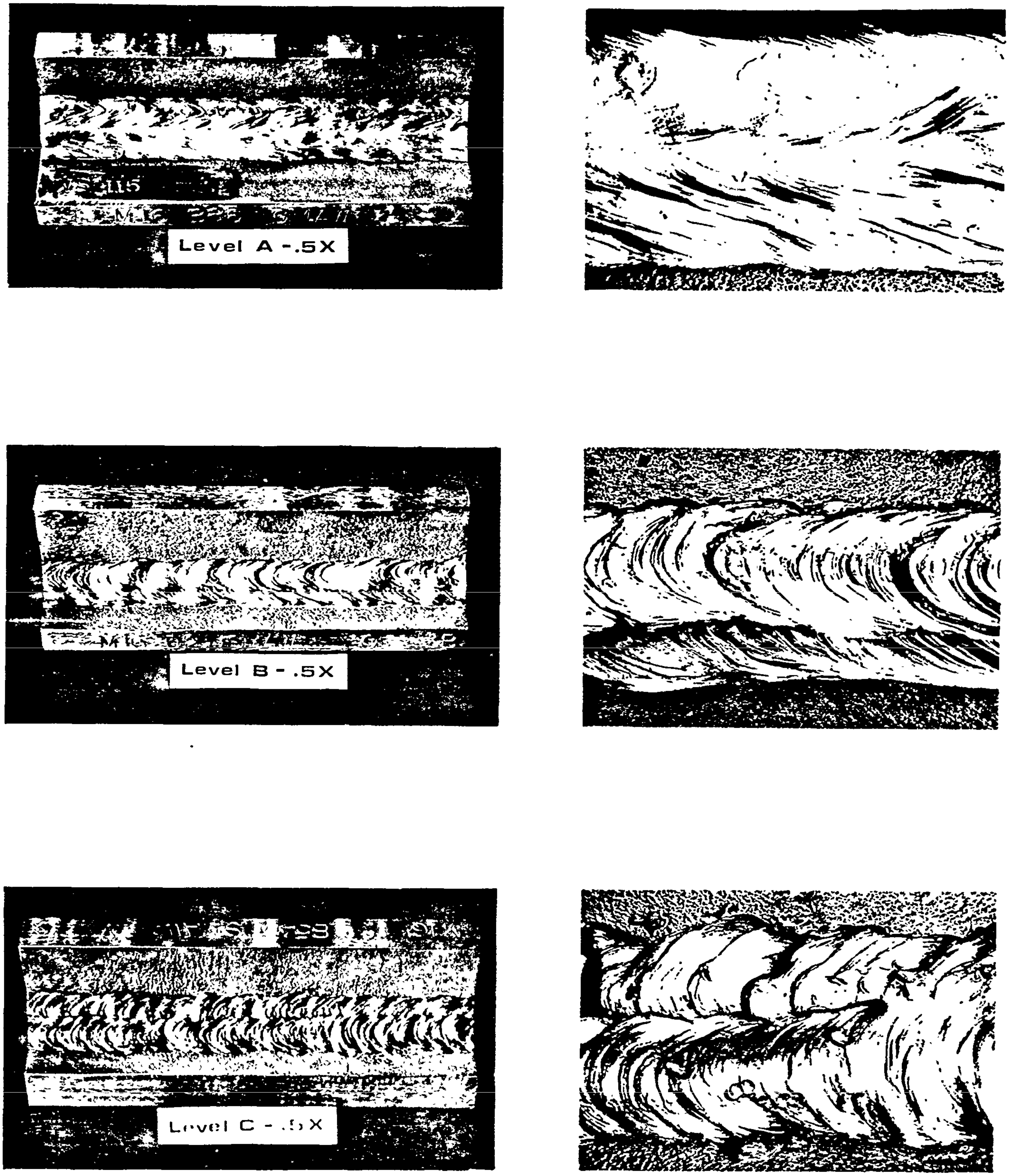

FIG. B: Undercut

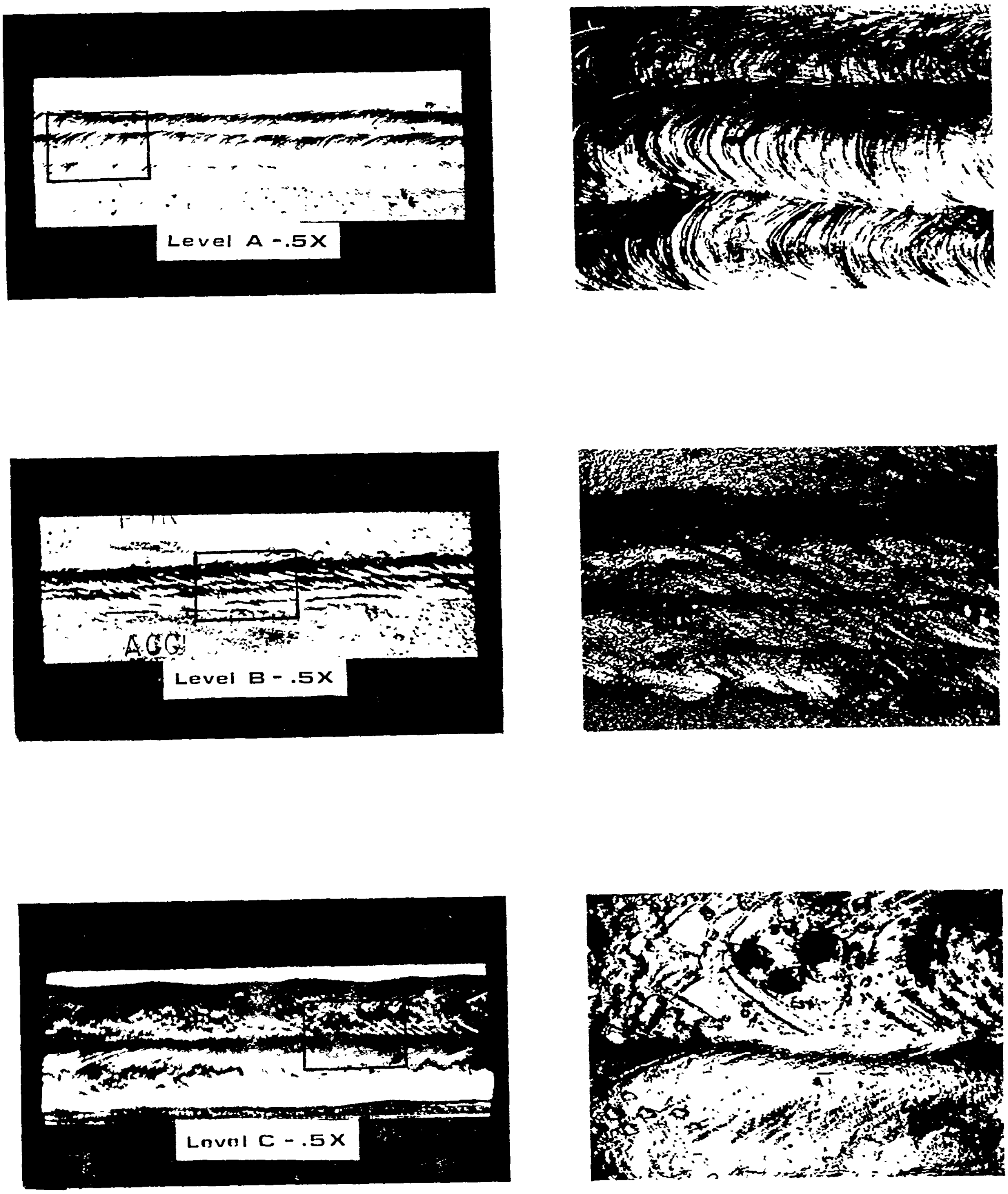

FIG. C: Scattered Porosity

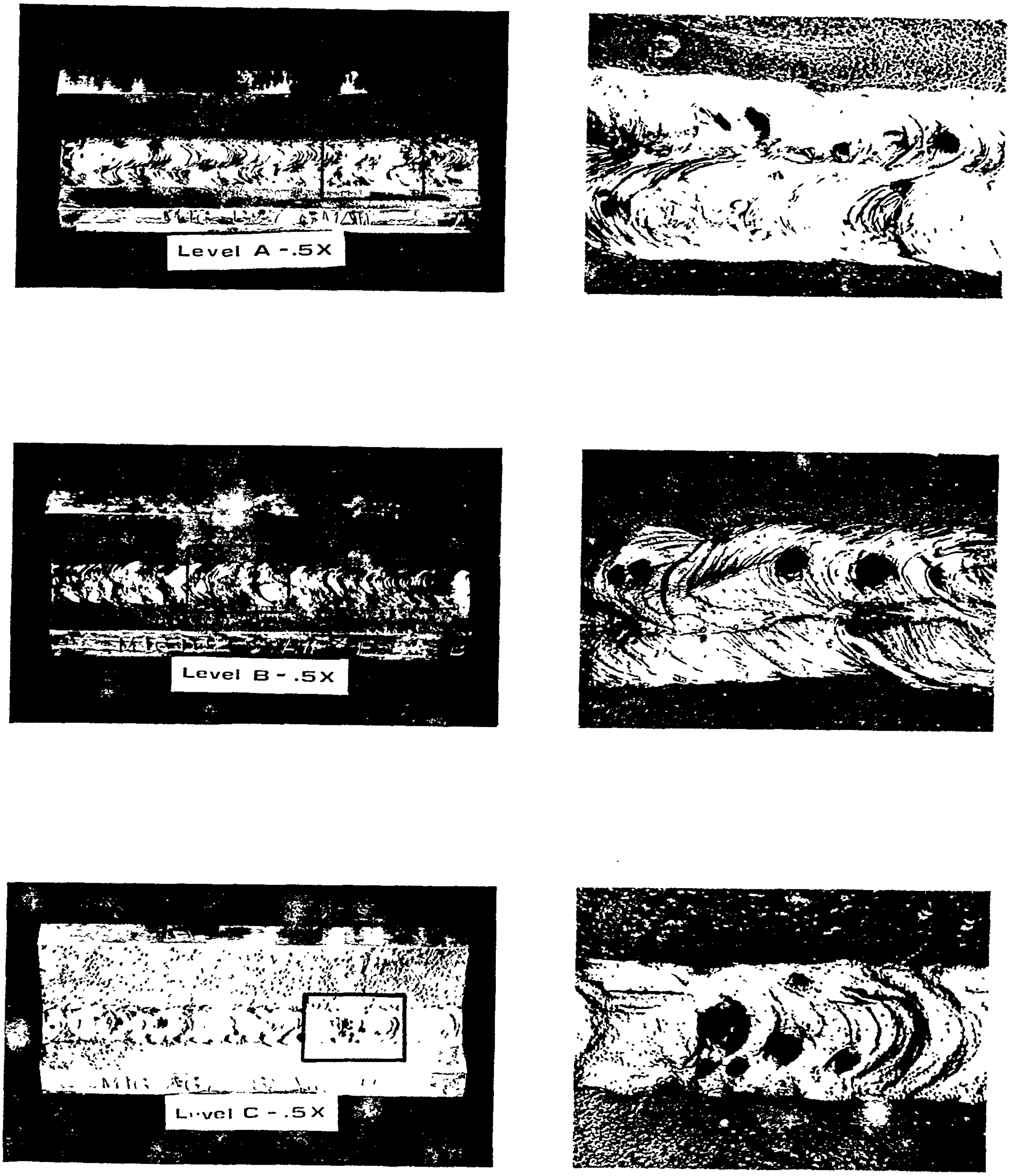

FIG. D: Scattered Porosity

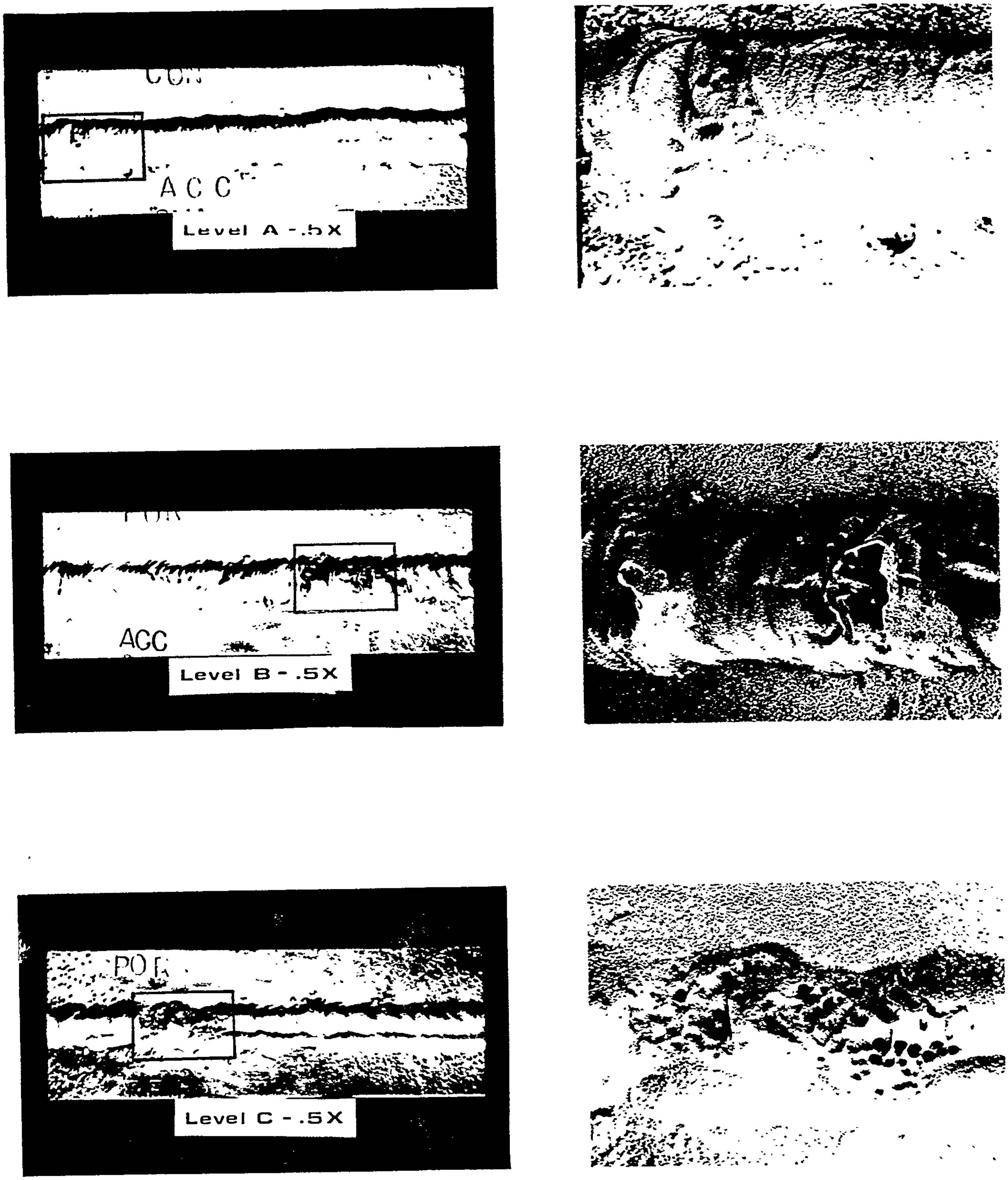

FIG.E: Cluster Porosity

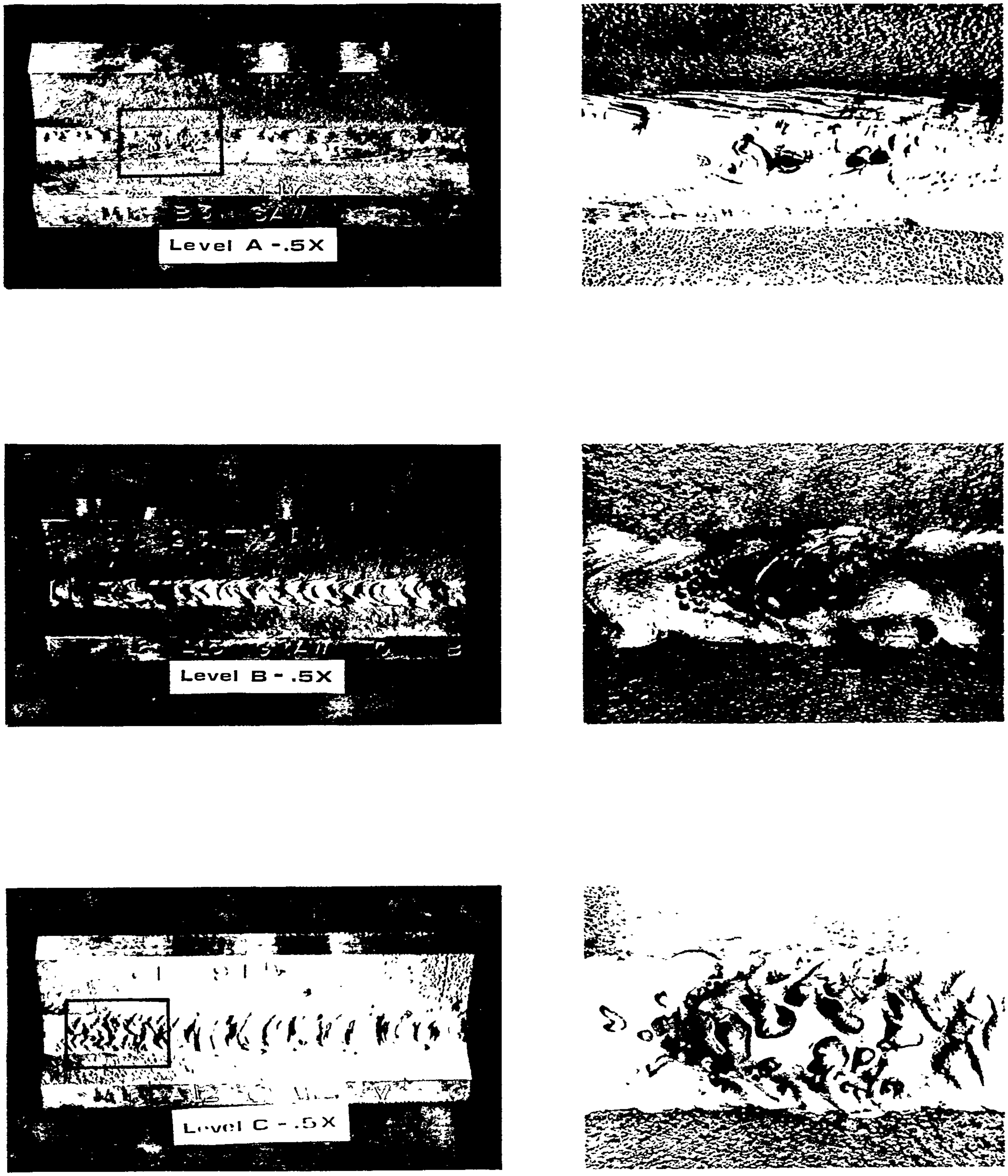

FIG.F: Cluster Porosity

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